conductivity type GaN group semiconductor formed on a crystal substrate, wherein the light receiving element comprises an ohmic electrode formed on a layer other than the light receiving layer.

8. (Twice Amended) A semiconductor light receiving element comprising a light receiving layer comprising a GaN group semiconductor and an electrode formed on one surface of the light receiving layer as a light receiving surface in such a manner that the light can enter the light receiving layer, wherein the light receiving element is a photoconductive type light receiving element, the light-receiving layer is a first conductivity type i layer, and the electrode formed on the light receiving surface is an ohmic electrode of one polarity, wherein the light receiving element comprises an ohmic electrode of the other polarity formed on the other surface of the light receiving layer directly or via a first conductivity type and low resistance GaN group semiconductor layer.

REMARKS

The Present Invention

The present invention relates to a light-receiving element comprising a GaN group semiconductor material.

The Pending Claims

Claims 2-12 are currently pending. Reconsideration of the pending claims is respectfully requested.

The Amendments to the Claims

The claims have been amended to more particularly point out and distinctly claim the present invention. In particular, claim 2 has been amended to recite that the light-receiving element is a Schottky barrier type light-receiving element in which light enters a depletion layer formed under the electrode, which extends to cover a small area around the electrode from the side the electrode is formed. Support for this amendment can be found, for example, on page 8, lines 27-31, of the specification. In addition, the grammar of claims 6 and 8 has been corrected. No new matter has been added by way of these amendments. The precise changes to the claims and the pending claims, as amended, are set forth on an attachments hereto.

Summary of the Office Action

The Office Action objects to claims 6 and 8 because of an informality. Claims 8, 10, and 11 are rejected under 35 U.S.C. § 102(b) as being anticipated by Manabe et al. (U.S. Patent 5,408,120). Claims 2-7 are rejected under 35 U.S.C. § 103(a) as obvious in view of Khan et al. (U.S. Patent 4,614,961) in combination with Nozaki (JP Patent 61-008979). Claim 9 is rejected under 35 U.S.C. § 103(a) as obvious in view of Manabe et al. (U.S. Patent 5,408,120) in combination with Berger et al. (U.S. Patent 5,777,390). Finally, the Examiner rejects claim 12 under 35 U.S.C. § 103(a) as obvious in view of Manabe et al. (U.S. Patent 5,408,120) in combination with Nozaki (JP Patent 61-008979).

Discussion of the Objection

The Examiner objects to the phrase "which element comprising" in claims 6 and 8. These claims have been amended to recite "wherein the light receiving element comprises." In view of the amended claims, the objection should be withdraw.

Discussion of the Anticipation Rejection

According to the Examiner, Manabe et al. teaches a semiconductor light-receiving element comprising a light-receiving layer comprising a GaN semiconductor and an electrode as recited in claim 8. Allegedly, Manabe et al. also discloses specific properties of the electrode that are recited in claims 10 and 11.

Manabe et al. discloses a *light-emitting* device comprising a GaN compound semiconductor with an n-layer of an n-type GaN compound semiconductor and an i-layer of an i-type GaN compound semiconductor. This i-layer functions as a *light-emitting* layer. In contrast, the present invention, as defined by claims 8, 10, and 11, is directed to a photoconductive type light-receiving element, wherein the i-layer functions as a *light-receiving* layer. The i-layer in the *light-emitting* element of Manabe et al. and the i-layer in the *light-receiving* element of the present invention have substantially different functions. Therefore, the *light-emitting* element of Manabe et al. and the *light-receiving* element of pending claims 8, 10, and 11 are completely different from each other, and Manabe et al. does not anticipate the present invention, as defined by claims 8, 10, and 11.

Moreover, Manabe et al. does not render the present invention obvious. Manabe et al. teaches that the luminous intensity is improved when an electrode with a large area is formed on an i-layer in the *light-emitting* element of Manabe et al. (col. 1, lines 26-30). An electrode with a large area formed on the i-layer (i.e., the i-layer surface is mostly covered by the electrode), as in Manabe et al., reduces the amount of incident light and degrades the sensitivity. In contrast, in the *light-receiving* element of the present invention, light enters a

depletion layer formed under the electrode, which extends to cover a small area around the electrode from the side the electrode is formed (see Figure 4(a) of the specification). Therefore, the structure itself of the *light-emitting* element of Manabe et al. is completely different in comparison to the structure and relative component sizes of the *light-receiving* element of the present invention. Nothing in Manabe et al. would teach or suggest modifying the *light-emitting* element, in particular the relative sizes of the electrode and i-layer, in order to arrive at the *light-receiving* element of pending claims 8, 10, and 11. Accordingly, the *light-receiving* element of claims 8, 10 and 11 of the present invention is novel and unobvious in view of Manabe et al., and the rejection should be withdrawn.

Discussion of the Obviousness Rejections

(A) Claims 2-7

Khan et al. allegedly discloses a semiconductor light-receiving element with all of the properties recited in claim 2 except for the property that the total of boundary lines between areas of the light receiving surface covered by the Schottky electrode and exposed areas is longer than the length of the outer periphery of the light receiving surface. The Examiner contends it would have been obvious to look to the teachings of Nozaki for this element in order to optimize the area needed to receive light and minimize the outer periphery. The Examiner makes similar allegations with respect to claims 3-7.

Khan et al. discloses a UV detector **10** comprising a sapphire substrate **11**, a buffer layer **12**, an $Al_xGa_{1-x}N$ layer **14**, and a Schottky barrier **15**, which are laminated together successively (see Figure 1). The Schottky barrier type light-receiving element of Khan et al. has a light-receiving area characterized by a depletion layer extending toward the semiconductor side on the semiconductor **14**/Schottky electrode **15** interface. In the detector of Khan et al., the light to be detected enters the depletion layer (i.e., the light-receiving area) from the side *opposite* to the side on which a Schottky electrode used to block the light is formed (i.e., from the side *opposite* from the element) (see Figure 1). In comparison, in the light-receiving element of pending claim 2, light enters a depletion layer, which is formed under the electrode and extends to cover a small area around the Schottky electrode, from the side the electrode is formed (i.e., from the *surface* side of the element) (see Figure 4(a) of the specification). Therefore, the detector of Khan et al. and the light-receiving element described in claim 2 of the present invention have completely different structures.

Nozaki et al. discloses a photovoltaic device comprising a first conductivity type polycrystalline silicon layer **12** and a second conductivity type microcrystalline silicon layer **13** laminated on layer **12**. A lattice-like collecting electrode **15** is formed on the surface of

layer **13** via a transparent conductive film **14**. This lattice-like collecting electrode **15** is formed for the purpose of collecting electrons from the transparent conductive film **14**.

In the light-receiving element of claim 2 of the present invention, the length of the periphery of the electrode (i.e., the total of boundary lines between areas of the light receiving surface covered with the Schottky electrode and exposed areas) should be longer than the length of the outer periphery of the light-receiving surface for the active use of the depletion layer, which is formed under the electrode and extends to cover a small area around the electrode (see Figure 4(a) of the specification). In contrast, in the photovoltaic device of Nozaki et al., the collecting electrode **15** is formed to collect electrons from the transparent conductive film **14**. Thus, the size of the window through which the light passes and the area of the electrode are important factors in the device of Nozaki et al., whereas the length of the periphery of the electrode is not particularly important. In short, Nozaki et al. does not teach or suggest that the total of boundary lines between areas of the light-receiving surface covered with the Schottky electrode and exposed areas is longer than the length of the outer periphery of the light-receiving surface.

If the disclosures of Khan et al. and Nozaki et al. were combined, the obtained device would not result in the invention of pending claim 2. Neither reference, either alone or in combination, teaches or suggests the structure of the light-receiving element of the present invention, not to mention the feature in which the total of boundary lines between areas of the light-receiving surface covered with the Schottky electrode and exposed areas is longer than the length of the outer periphery of the light-receiving surface. In the absence of a teaching or suggestion of all the elements of the present invention, the cited references cannot be said to render pending claim 2 obvious.

Claims 3-7 are directly or indirectly dependent on claim 2 and accordingly contain all of the elements of claim 2. The cited references do not render pending claims 3-7 obvious for the same reasons discussed above with respect to claim 2. Therefore, the present invention as defined by claims 2-7 is not obvious from the teachings of Khan et al. in view of Nozaki et al. and the rejection should be withdrawn.

(B) Claim 9

According to the Examiner, Manabe et al. teaches all the elements of claim 9 except that the ohmic electrode of one polarity is transparent. Berger et al. allegedly teaches such an electrode, and the Examiner states that it would have been obvious to combine the two disclosures in order to provide an electrode that enhances speed and conductivity.

As discussed above, the invention of Manabe et al. relates to a *light-emitting* element, which has a completely different structure from the *light-receiving* element of the present

invention. Berger et al. does not satisfy the deficiencies of Manabe et al. Berger et al. discloses a metal-semiconductor-metal (MSM) type light-receiving element. The MSM-type light-receiving element operates in a completely different manner from that of a photoconductive type light-receiving element, such as the present invention. In the MSM-type light-receiving element, an electric field is applied in advance to the anode and cathode, and light is allowed to enter. Of the charge carriers produced by the incidence of light, the negative charge is attracted to the anode, and the positive charge is attracted to the cathode, thereby generating a photocurrent. In this type of light-receiving element, a high speed response is difficult to obtain because the travel speed of the positive charge is slower than that of the negative charge. In order to obtain a high speed response, the MSM-type light-receiving element of Berger et al. typically comprises a transparent cathode to create a positive charge near the cathode.

In comparison to an MSM-type light-receiving element, changes in the resistance between the two electrodes are monitored in a photoconductive type light-receiving element. Of the two electrodes, only one electrode is formed on a light-receiving surface. When the electrode has a large area, even a small change in the resistance can be detected, and the sensitivity of the response level is maintained. However, the sensitivity is ultimately degraded because the amount of the incident light decreases due to the opaqueness of the electrode. The light-receiving element of pending claim 9 serves to solve this problem by requiring that the ohmic electrode of one polarity is formed as a transparent electrode to permit the entry of light, which in turn increases sensitivity.

Therefore, the structure of the light-emitting element disclosed by Manabe et al. is completely different than the light-receiving element of pending claim 9, or even the light-receiving element disclosed by Berger et al. Moreover, the transparent electrode disclosed by Berger et al. is for a completely different type of light-receiving element and serves a different purpose than that of the light-receiving element of pending claim 9. As such, while one of ordinary skill in the art would not be motivated to combine the different disclosures of Manabe et al. and Berger et al., even if the two disclosures were combined, the obtained product would not be the invention of claim 9. In view of a lack of motivation to combine the references and the failure of the cited references to disclose all of the elements of the present invention as defined by claim 9, claim 9 must be considered unobvious in view of Manabe et al. and Berger et al. Accordingly, the rejection of claim 9 should be withdrawn.

(C) Claim 12

The Examiner contends that Manabe et al. teaches the elements of claim 12 except for the ohmic electrode of one polarity having a comblike pattern but asserts that it would have been obvious to add such a feature based on the teachings of Nozaki.

Again, as discussed above, the invention of Manabe et al. relates to a *light-emitting* element, which has a completely different structure from the *light-receiving* element of the present invention. Moreover, Nozaki et al. does not teach or suggest the photoconductive type light-receiving element of the present invention. Therefore, even if the disclosures of Manabe et al. and Nozaki et al. were combined, the product resulting from the combination of the disclosures would not be the present invention as defined by claim 12. Neither reference teaches or suggests modifying the disclosed products in order to arrive at the light-receiving element of pending claim 12. Without such a teaching or suggestion, neither Manabe et al. nor Nozaki et al., alone or in combination, renders the present invention obvious. Therefore, the present invention, as defined by claim 12, is unobvious in view of the cited references, and the rejection should be withdrawn.

Conclusion

The application is considered to be in good and proper form for allowance, and the Examiner is respectfully requested to pass this application to issue. If, in the opinion of the Examiner, a telephone conference would expedite the prosecution of the subject application, the Examiner is invited to call the undersigned attorney.

Respectfully submitted,

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